

Characterization of dust aerosols in the infrared from IASI and comparison with PARASOL, MODIS, MISR, CALIOP, and AERONET observations

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Remote sensing of dust aerosols in the IR

Why study aerosols in the infrared ?

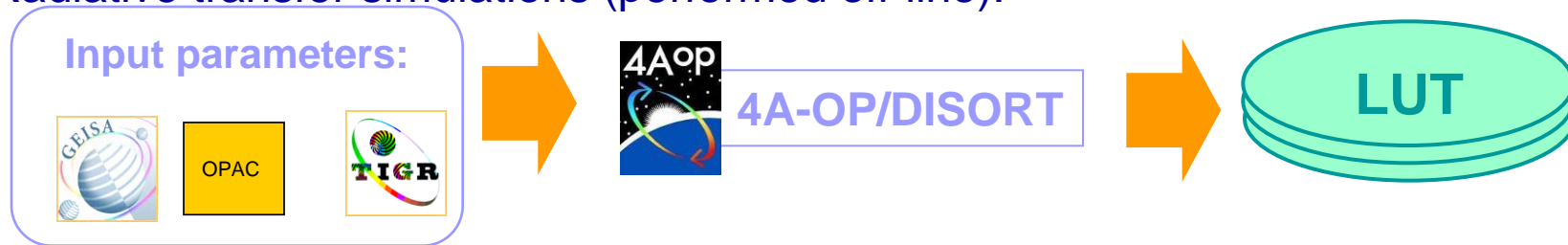
- Observations available **daytime** and **nighttime**, over ocean and over **land**
- Access to the **mean aerosol layer altitude**
- 10 μm : preferential detection of **dust aerosol coarse mode**

... **But :**

- ❗ Sensitivity to atmospheric thermodynamics
- ❗ Sensitivity to surface properties

Method:

1. Radiative transfer simulations (performed off-line):



2. Inversion → proximity recognition within the Look Up Table

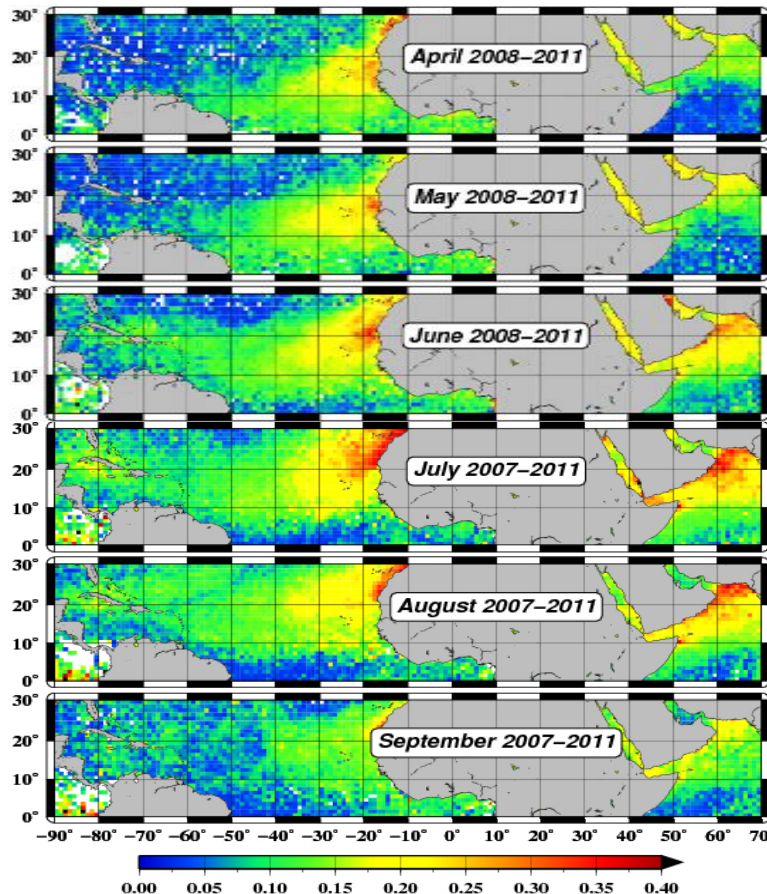
- ❖ determination of the atmospheric state (temperature, water profile)
- ❖ Simultaneous retrieval of both aerosol properties (AOD, altitude, effective radius)

Dust aerosol optical depth

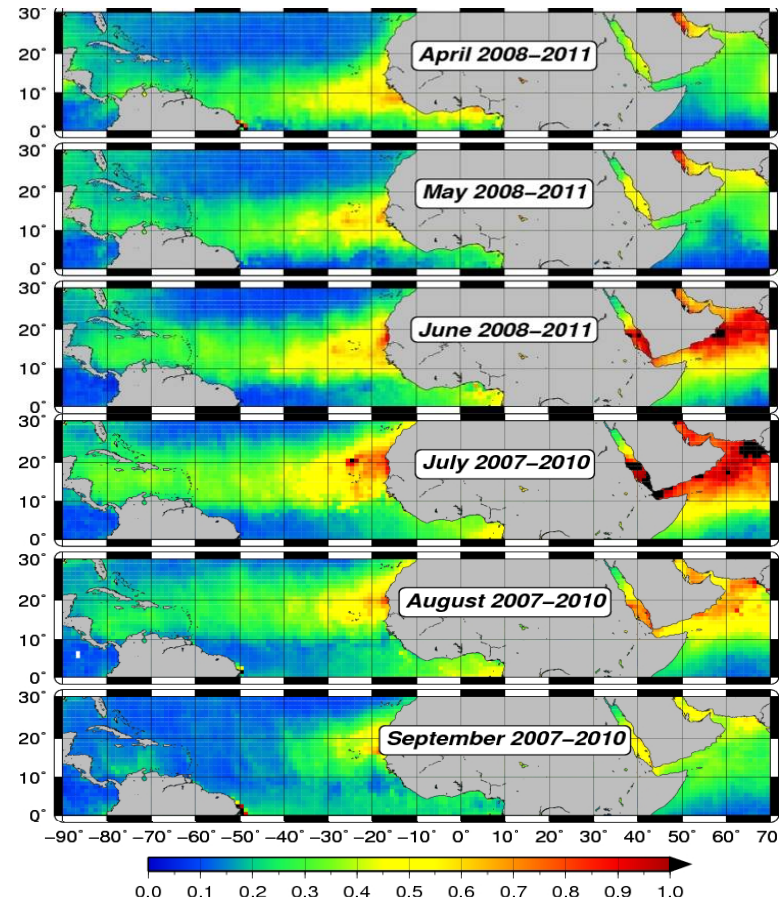
5 years (2007-2011) climatology (monthly 10 μm coarse mode AOD)

- Westward dust transport well reproduced.
- Comparisons with MODIS visible AOD (0.55 μm) show good agreement, keeping in mind the difference between the two AOD: IASI infrared AOD sensitive mainly to the coarse-mode and MODIS visible AOD mainly representative of the fine mode.

IASI AOD (10 μm)

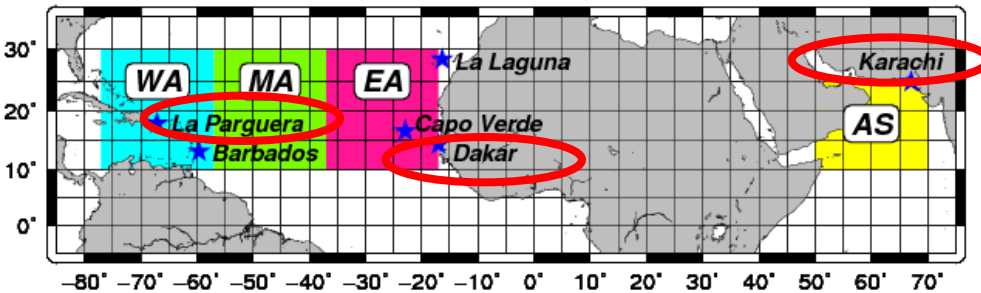


MODIS AOD (0.55 μm)



Dust aerosol optical depth

Results for regions 20° x 20° : comparison with visible AOD



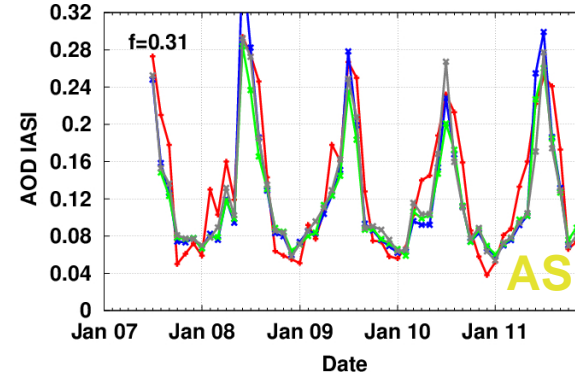
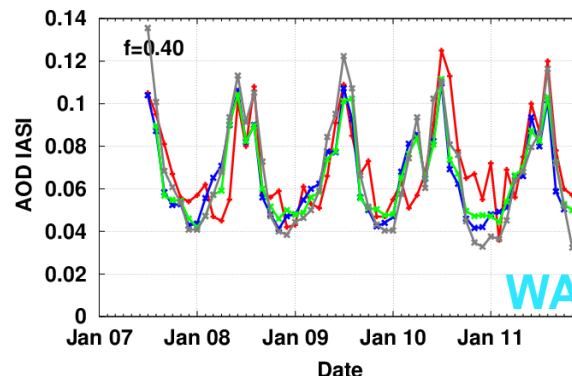
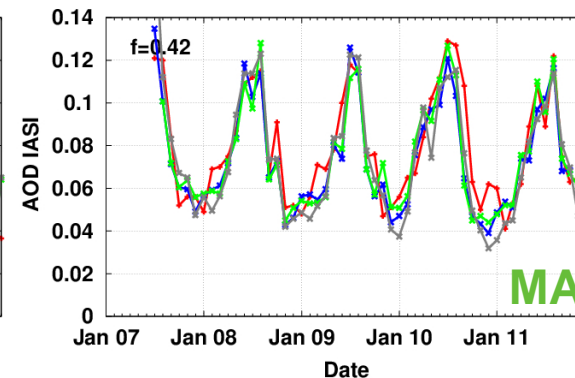
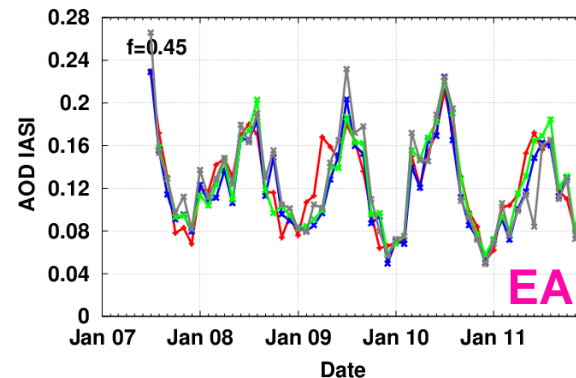
- IASI-AOD compare well with others, given a scaling factor of ~ 0.4 (explained by differences between coarse vs fine mode + IR vs visible)
- The 3 visible instruments also present differences between each other of the same order of magnitude than with IASI AOD
- scaling factor smaller for Arabia: due to a different dust model?

IASI - CM

MODIS - tot

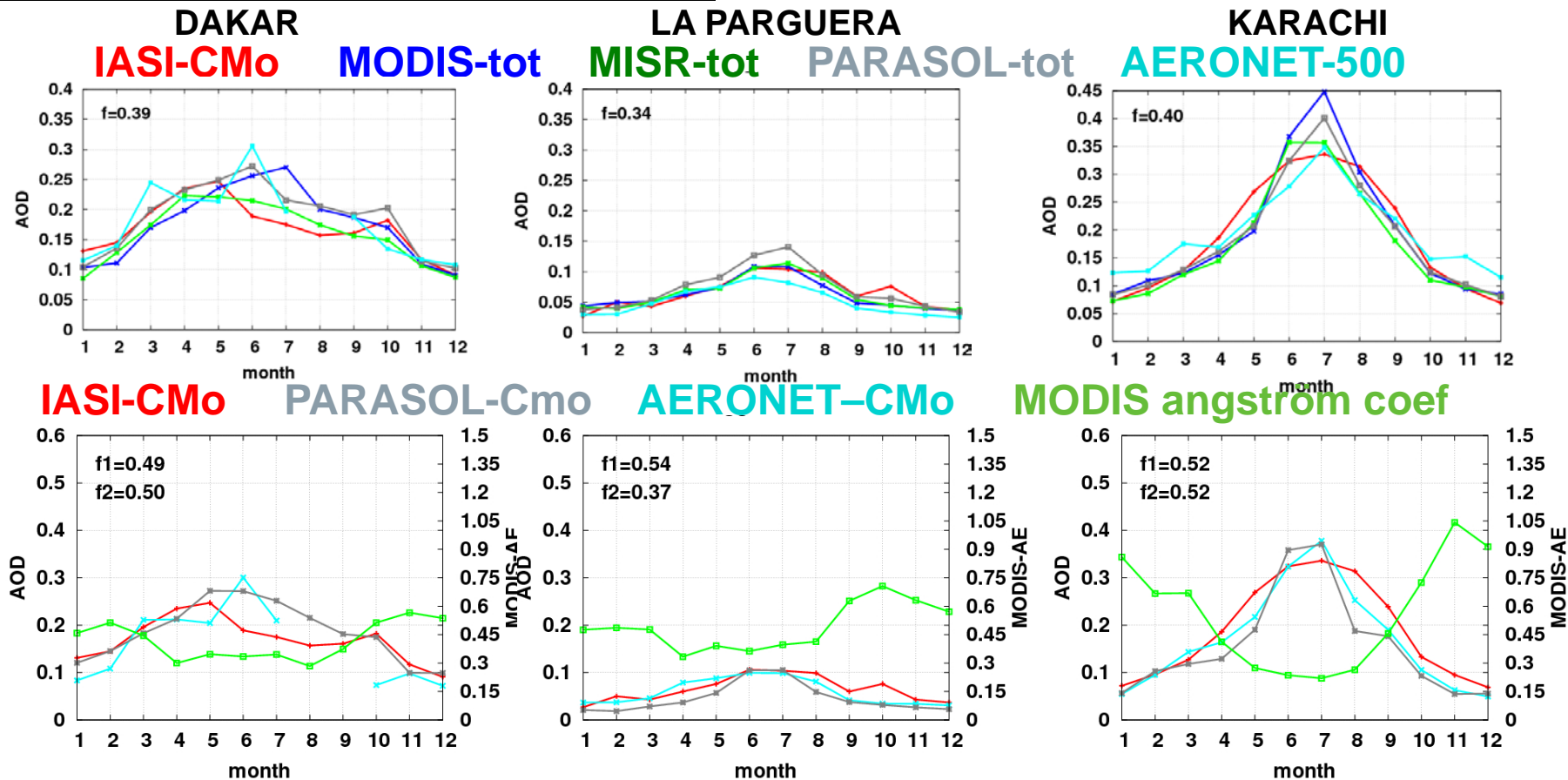
MISR - tot

PARASOL - tot



Dust aerosol optical depth

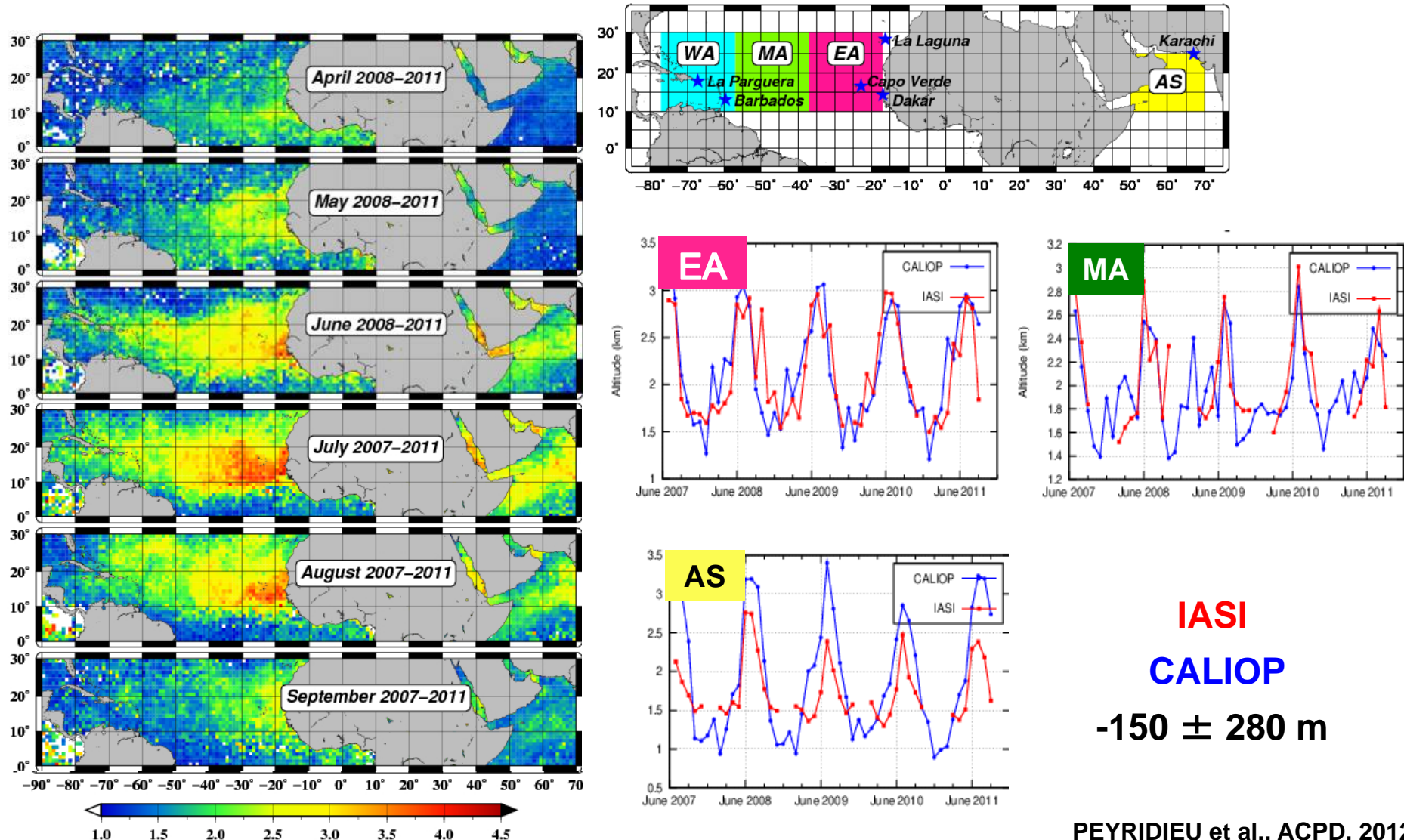
Results around AERONET sites 3° x 3° :



- Comparisons with other instruments still good at local scale.
- IASI AOD in phase with MODIS Angström Exponent : low AE corresponds to a predominant coarse mode (CMo).
- Correlation over 25 AERONET sites during the IASI period (~533 items) give a correlation between IASI and AERONET-CMo of $R=0.854$ (between AERONET and PARASOL CMo, both in the visible, $R=0.928$)

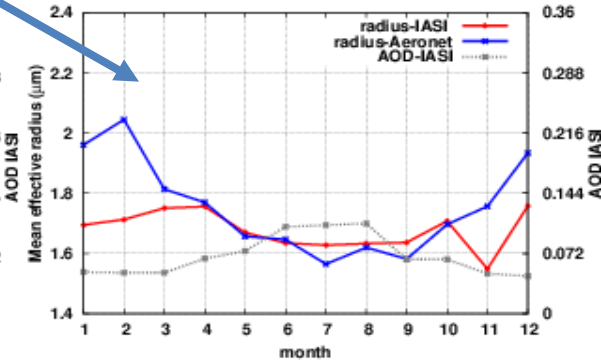
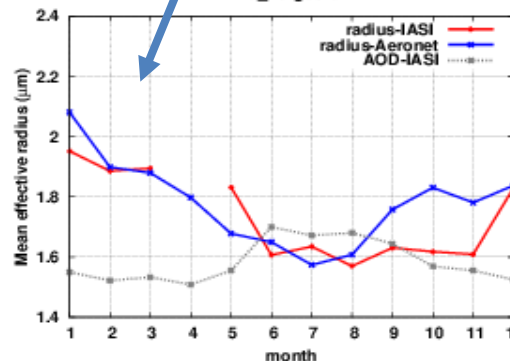
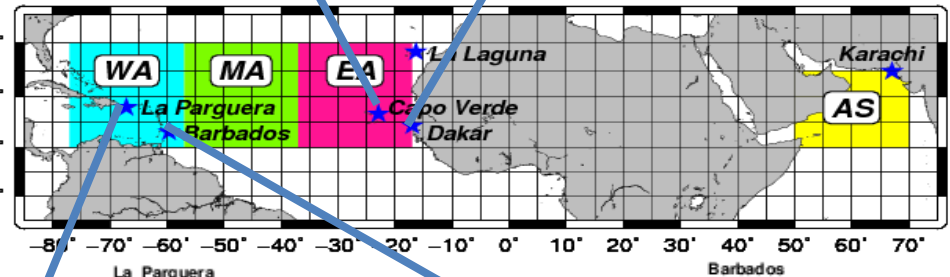
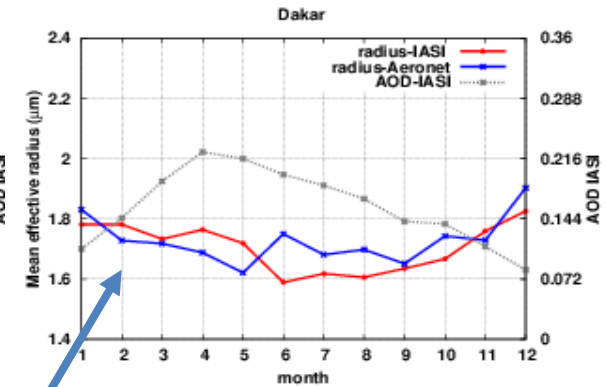
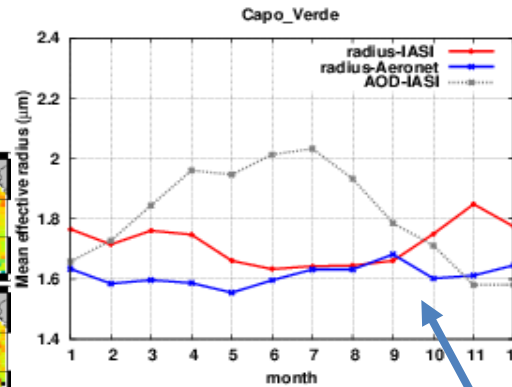
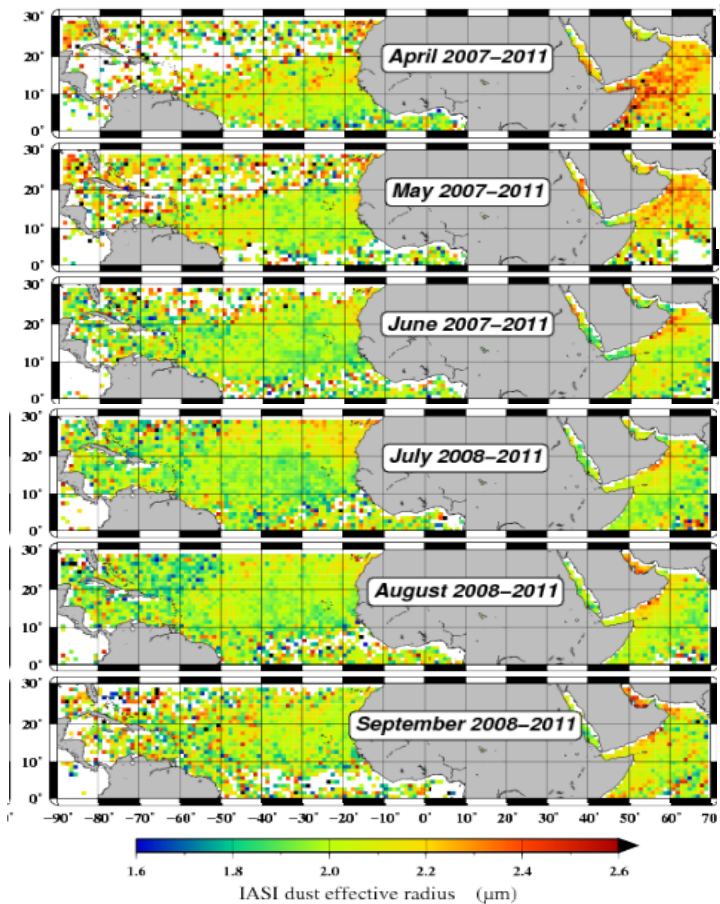
Dust aerosol mean altitude

- Results on mean altitude: climatology over 2007-2011 and comparisons with CALIOP altitudes



Dust effective radius

➤ Results on effective radius: climatology over 2007-2011 and comparison with AERONET

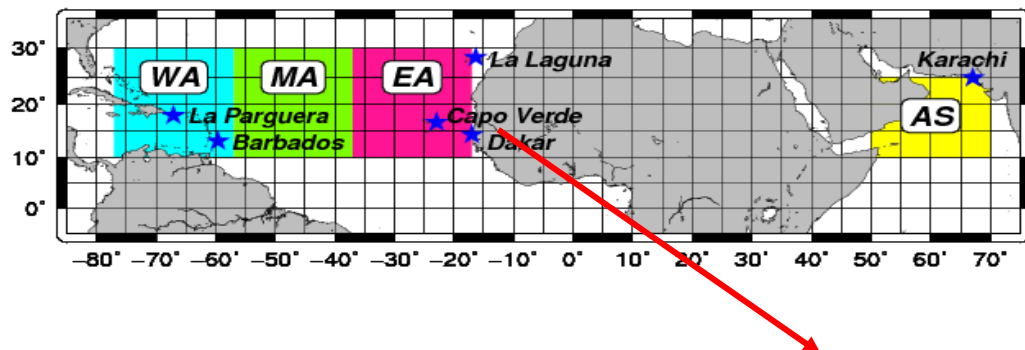


— IASI
— AERONET

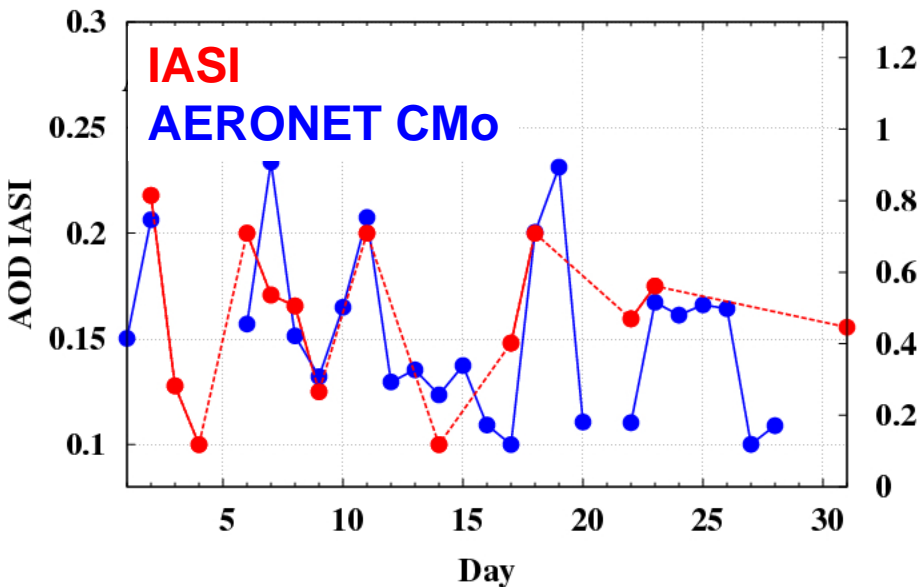
⚠ Unexplained bias of
+0.3 μm removed

Daily dust properties retrieval

COMPARISON WITH AERONET COARSE-MODE (CMo) AOD: 2 examples at Dakar



JULY 2009

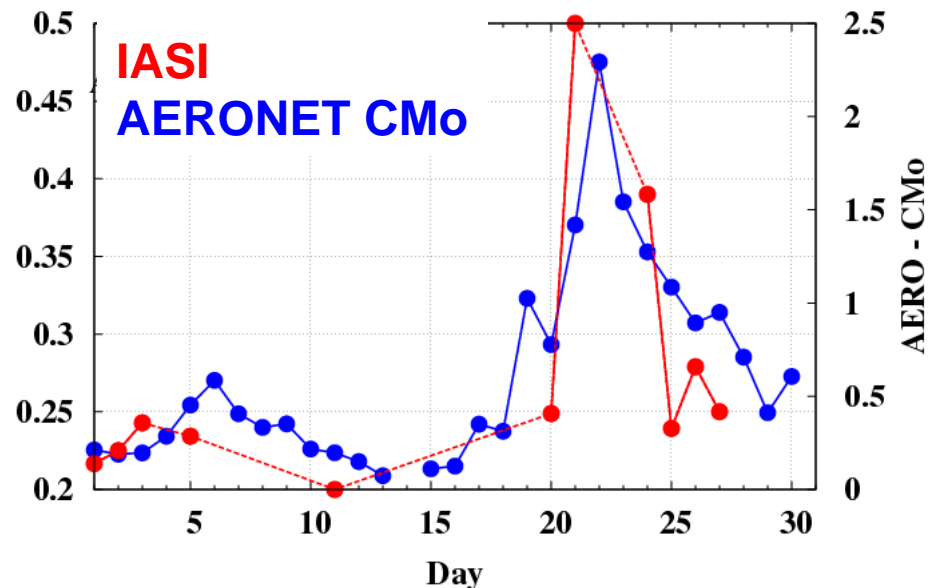


➤ July 2009 (dust season) :
IASI AODs well reproduce AERONET
observed variations

➤ March 2010 (outside the dust
season):

The dust event between March 21-25th
observed by AERONET also captured
by IASI

MARCH 2010

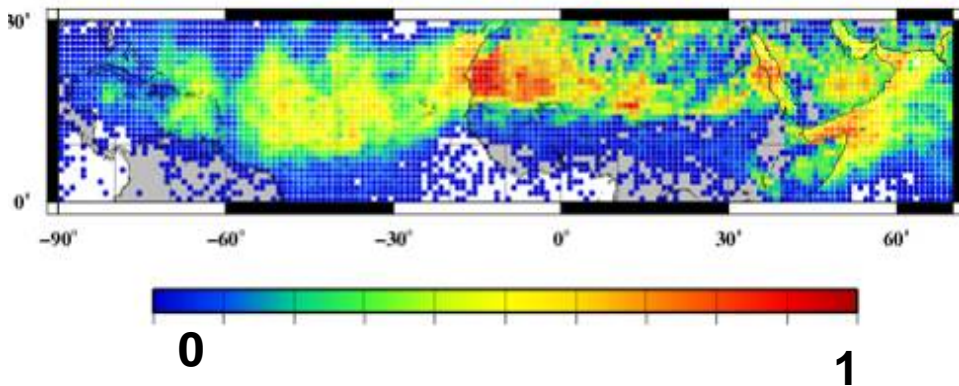


Dust Optical Depth retrieval over land

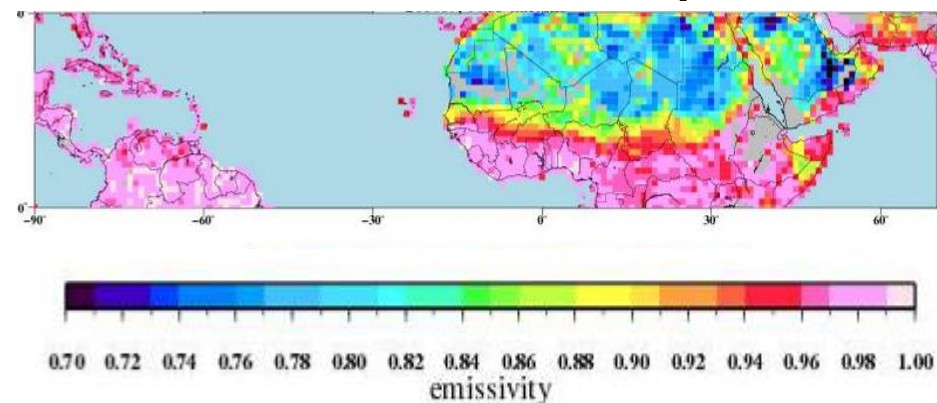
Retrieving aerosol properties above continents and particularly above desert :

- still challenging to achieve at solar wavelengths (mainly over desert)
- requires selection of cloud-free spots + aerosol flag over land
 - Use of a cloud/aerosol detection developed at LMD and based on the use of 12 threshold tests applied to differences between couples of channels IASI-IASI and IASI-AMSU.
- requires knowledge of the surface properties such as ϵ_s and T_s
 - Use of the IASI spectral emissivity at 0.05 μm resolution from 3.7 to 14.5 μm from Capelle et al., JAMC, 2012.

CLOUD-free AEROSOL FLAG

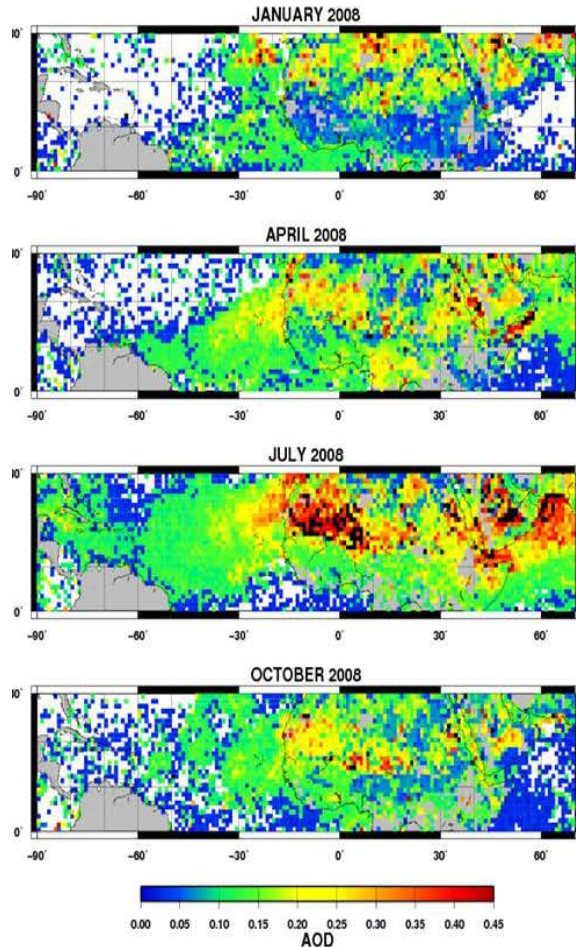


EMISSIONITY at 8.55 μm

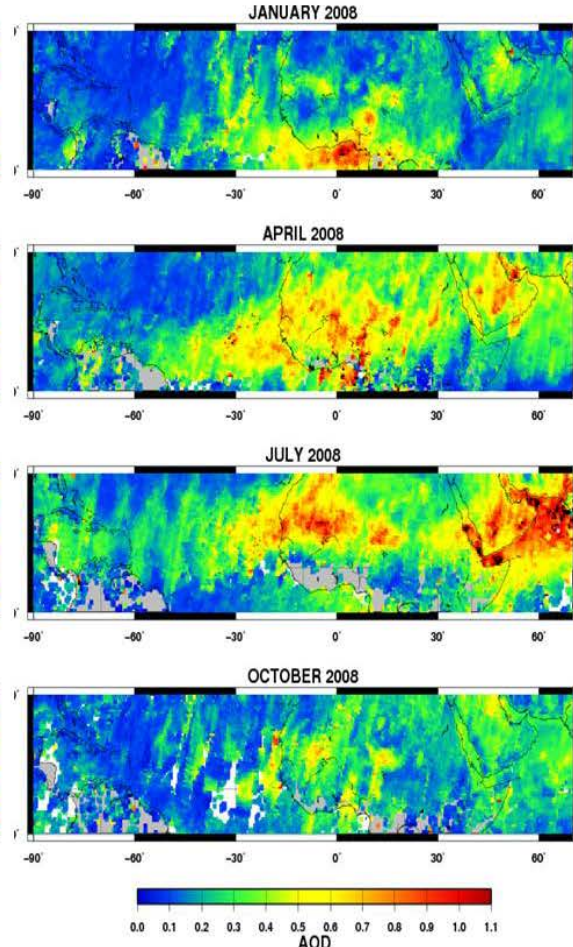


Dust Optical Depth retrieval over land

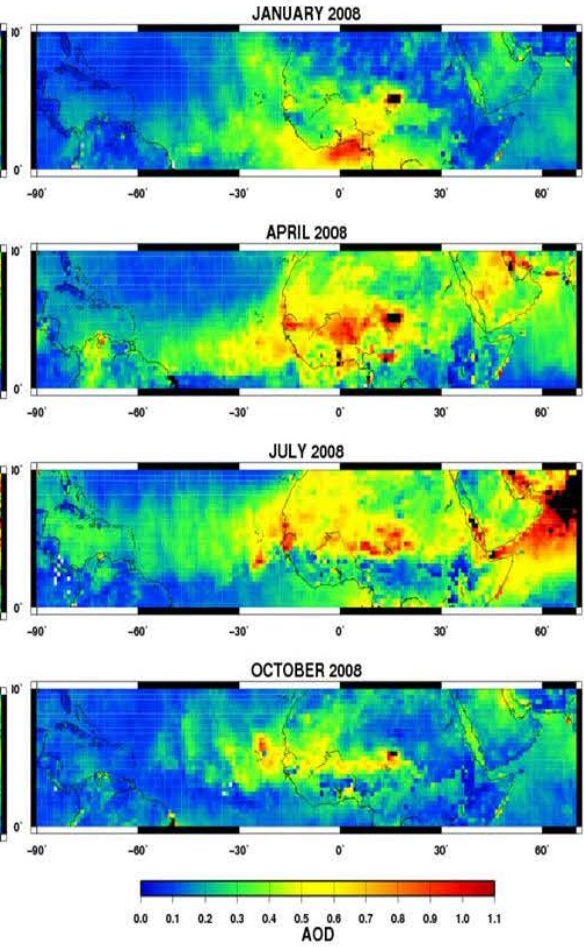
IASI 10 μm dust AOD



MISR 0.55 μm total AOD



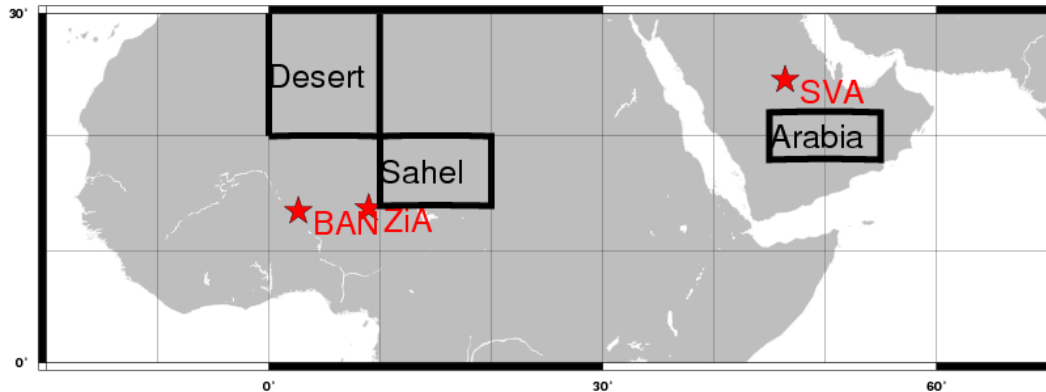
MODIS 0.55 μm total AOD



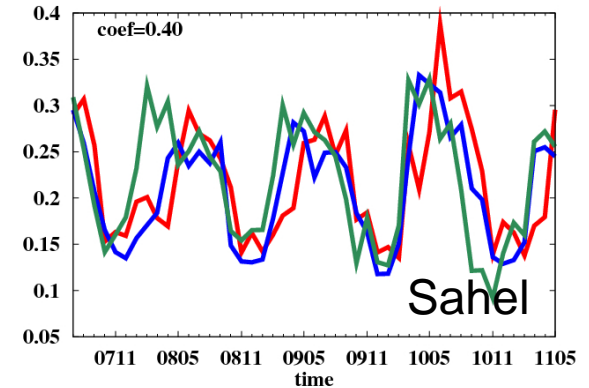
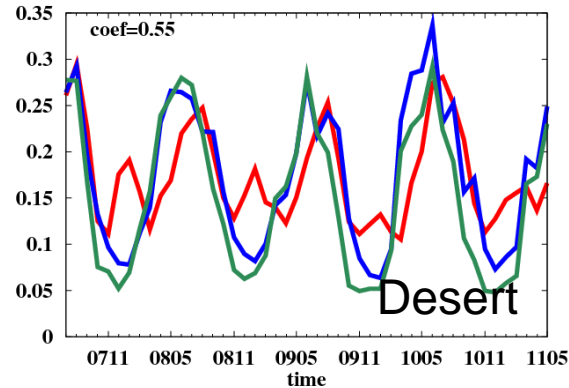
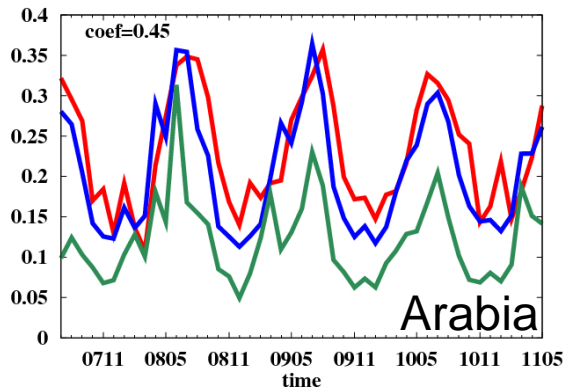
- ⇒ Good agreement with visible AOD (note also the differences between MISR and MODIS)
- ⇒ large differences mainly due to coarse mode versus fine mode (not seen in the IR) responses: example of smoke in January in the Guinea Gulf.

Dust Optical Depth retrieval over land

Time series for desert regions and comparisons with visible AOD



- Ratio IASI/Vis ~ 0.40 - 0.50 . Similar to what is found over sea
- IASI closer to MISR than to MODIS-DeepBlue
- AOD IASI larger than the other in winter \rightarrow due to some noise in winter linked to the sparse aerosol data for this season \rightarrow should be improved



IASI

MISR

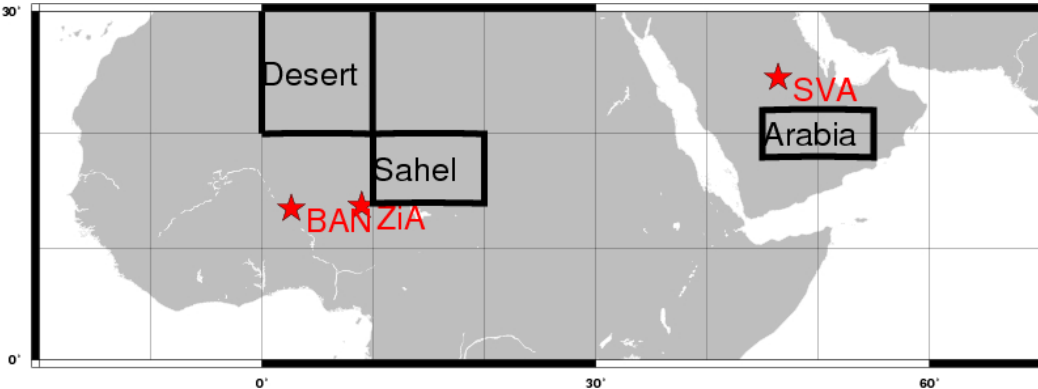
MODIS-DeepBlue

Dust Optical Depth retrieval over land

Time series for **AERONET sites** and comparisons with coarse-mode AOD

- IASI and AERONET CMo compare well, with ratio of ~ 0.5 .
- Comparisons have to be taken with care because of missing of AERONET data:

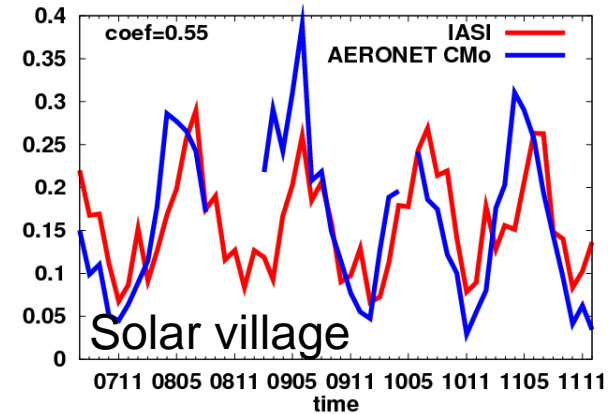
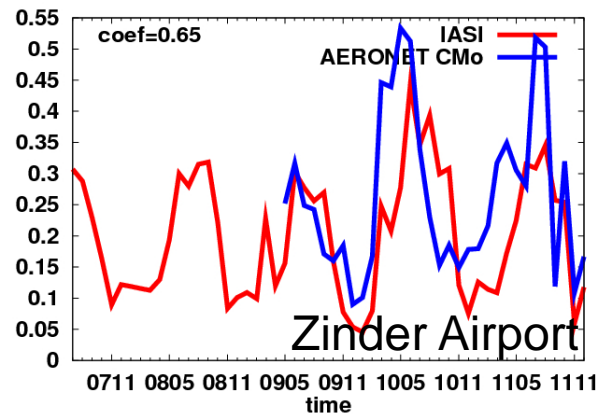
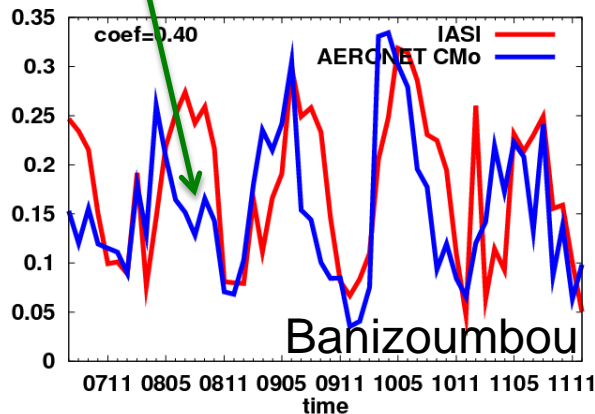
- discontinuous time series
- monthly averages calculated only from a few days of measurement
- Ex. for Banizoumbou in summer 2008: low AERONET AOD during the dust season explained by measurements performed out of the dust event



Missing
AERONET
data

IASI

AERONET CMo



Summary and perspectives

- **Dust retrievals ($10\text{ }\mu\text{m}$ AOD, altitude and particle size) over sea from IASI at $1^\circ \times 1^\circ$ monthly resolution:**
 - Time series from July 2007 to now
 - AOD validated against visible instruments such as MODIS, MISR, PARASOL or AERONET over large regions ($20^\circ \times 20^\circ$) or around AERONET sites ($3^\circ \times 3^\circ$)
 - Altitude consistent with CALIOP
 - Effective radius in agreement with AERONET values (except a still unexplained bias of $0.3\text{ }\mu\text{m}$)
- **Daily retrieval → currently under validation:**
 - First comparisons with AERONET-CMo in Dakar show promising results
- **Extension over land:**
 - First results show good agreement with MISR and to a lesser extent with MODIS-DeepBlue
 - Results are still too noisy, especially out of the dust season
 - Results on altitude still need improvement
- **Next step: Extension in latitude**
 - First step completed → extension of the cloud/aerosol mask flag
 - The next steps include: (i) check if an improvement of the channel selection is required; (ii), generate new LUTs with mid-lat atmospheric situations → to be completed soon